

F E A T U R E

A R T I C L E

Examining the Benefits of Learning Based on an Audience Response System When Confronting Emergency Situations

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An audience response system (ARS) is a technology that allows students to respond electronically to questions that lecturers pose in class by using a handheld piece of equipment.¹ An ARS is also known as a classroom response system, a personal response system, or simply a “clicker.” From here on, we shall use the term ARS to refer to this concept.

Audience response system use was first introduced by the military in the 1950s.² As early as the 1960s, higher education science faculties used ARS for stimulus response techniques in the classroom.² It was later used at Stanford University in 1996.³ The system was, at that time, complex, and devices were expensive. More cost-effective and user-friendly devices are currently within everyone’s reach, thus increasing faculty acceptance in diverse disciplines.⁴ Response technologies in the classroom are now being used in many universities in general and in nursing education in particular.^{5–8} An ARS traditionally requires three elements: (1) a software polling program to prepare and launch tests, (2) a handheld remote device to respond to questions that lecturers pose in class, and (3) a response receiver that plugs into a USB port.⁹ The polling program can usually be integrated into presentation software such as Microsoft PowerPoint. Recent advances in ARS technology have resulted in software that allows students to connect via Web-enabled cell phones.^{10–12}

Some of the benefits of using an ARS are (1) the creation of active learning environments and provision of

This article presents an empirical study on the effectiveness of the use of an audience response system called Sistema De Respuesta inmediata de la Audiencia on a nursing course. A total of 130 students of mixed gender, age, and computer experience and educational background on a third-year course in nursing administration and management participated in the study. The benefits of an audience response system as regards learning how to confront emergency situations were studied. The innovative aspect of the proposal is twofold: (1) the use of a smartphone to respond to the questions and (2) the analysis of the students’ response time when confronting critical situations while managing nursing resources. A positive impact on the students’ performance was revealed in their final assessments. Our findings show that Sistema De Respuesta inmediata de la Audiencia increases student participation and aids in identifying and correcting misconceptions. The students found Sistema De Respuesta inmediata de la Audiencia to be very motivating and wanted it to be used in additional lectures. Further research is required to study the effectiveness of Sistema De Respuesta inmediata de la Audiencia for it to be widely used in other disciplines.

KEY WORDS

Audience response system •
Computer-assisted instruction • Education •
Evaluation • Nursing

a fun atmosphere during class, (2) the creation of safe environments for timid students, (3) the capability to collect and analyze student feedback quickly (and anonymously)

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during class, and (4) improvements to the interaction between the faculty and its students.^{11,13–22} These benefits increase students’ preparation, and attendance in class.^{3,18} Its weaknesses include technology malfunction, the cost of the remote devices, and inexperienced teachers who are unable to provide instant feedback, which may alter their instructional strategies.^{3,23,24}

LITERATURE REVIEW

In recent years, the use of ARS has been accurately studied in all types of college curricula, principally to create active learning environments and thus demonstrating their potential as regards improving the engagement and motivation of undergraduate nursing students.^{6,11,14,25}

Audience response systems have been used in undergraduate nursing, nursing pediatrics, nursing therapeutics, medical-surgical nursing, nursing anatomy and physiology, nursing emergency, nursing pharmacology, and nursing ethics.^{23,26–33} A review of the literature related to “clicker” use in health-related disciplines has reported that most of the studies have taken place in the United States.³⁴

Three major findings emerge in literature as regards the impact of ARS use: (1) improvement of interactivity and participation, (2) increase in satisfaction and learning outcomes, and (3) support of formative assessment and contingent teaching.^{23,30–32,34–36}

The objective of this article was to study the benefits of ARS when learning how to confront emergency situations. Audience response systems have been used to collect an-

swers to multiple-choice questions (MCQs) and capture their response times in various case studies. These data have then been analyzed to measure the students’ performance and their ability to react in situations in which time is of the essence. Emergency situations are contextualized in a course on the administration and management of nursing resources. To the best of our knowledge, no other studies related to ARS and nursing have analyzed the impact of ARS use on student learning in emergency situations by using response times.

SISTEMA DE RESPUESTA INMEDIATA DE LA AUDIENCIA E-LEARNING SYSTEM

Sistema De Respuesta inmediata de la Audiencia (SIDRA) is a free and publicly available client-server tool that was created to collect and analyze responses to questions proposed by a survey taker, in our case, an instructor. A group of MCQs prepared under a specific criterion and labeled with a name is called a test. SIDRA has both Web-based and mobile-based interfaces, which are different for the students and teachers. It can currently be downloaded from the Apple App Store and from Google Play. For example, a student can access the description of the MCQs, respond to the questions, and view the percentage of answers to each question at the end of the online session (Figure 1). In contrast, a teacher can prepare an MCQ test, launch a test, export the results of a test, and view the statistics of students’ answers. SIDRA works as follows:

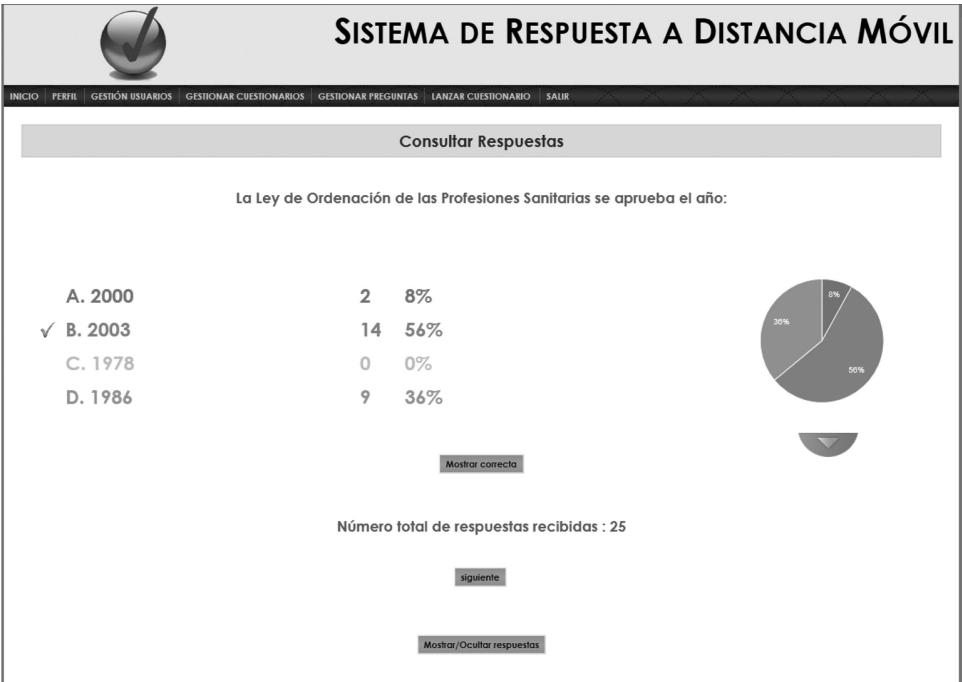


FIGURE 1. Dashboard of the SIDRA teacher interface.

1. The instructor launches an MCQ test, which is available on the students' Web interface. These descriptions present problems related to the concepts studied in class.
2. The students can select the answers to each MCQ in a time interval determined by the instructor. A user-friendly interface based on the traffic light metaphor is used: red—not allowed to respond; green—allowed to respond; orange—respond with caution, difficult question.
3. SIDRA's server receives the students' answers, compares them with the answer expected, and records each student's response times.
4. At the end of the MCQ test, SIDRA shows statistical information concerning the student's answers: response times, average response time, percentage of correct answers, and so on.
5. Additional information on correct answers and the students' response times to each MCQ test can be accessed by teachers. The system also includes tools with which to send comments about any question and ask the teachers questions.

METHODS

Detailed information about the method followed is provided in this section.

Aims

The aim was to assess the use of the SIDRA system when teaching the skills needed for the provision of prompt medical care in emergency situations on an Administration and Management of Nursing Resources (AMNR) course. The following hypotheses are proposed in this study:

- (a) Hypotheses 1: The final examination grades of the students who have used SIDRA will be higher than those of the students that have not.
- (b) Hypotheses 2: Scores in SIDRA are linearly correlated with the grade in the final examination.
- (c) Hypotheses 3: Students are satisfied when using SIDRA.

Participants

SIDRA was used in a first-term course on nursing administration and management at the University of Murcia. The AMNR is a third-year course that focuses on developing knowledge and skills as regards planning, organizing, directing, and evaluating an organization and institution of society, service, social system, or component of a health-care system. The aim of this course is to develop the students' potential in various everyday situations, emergency situations, health promotion, disease prevention, and the care of ill or disabled people. The AMNR takes place during a 15-week period. The students attended 3 h/wk of lectures and 35 hours of practice.

Experiment

An experiment was conducted during the academic year 2012/2013 to investigate the educational effectiveness of SIDRA. Recruitment took place in a preparatory session, which all the students in the sample population were required to attend. The students were informed of the purpose and design of the study, the students' commitment to the experiment, and the tasks to be performed via a short verbal presentation by an experienced coordinator in class. The students were assured that there would be no penalty for withdrawal from the study.

A total of 130 students of mixed gender, age, computer experience, and educational background gave oral consent to participate in the study. Institutional review board approval was obtained from the university prior to recruitment.

Design

All of the students enrolled in the study. The students in the morning session comprised the experimental group ($n = 58$), whereas those in the afternoon session comprised the control group ($n = 72$). The students in the experimental group used SIDRA, whereas those in the control group received the same training but without using an ARS. The same faculty member facilitated the course in both the morning and afternoon sessions.

Data were collected at several time points during the study. Baseline data, generated from a demographic questionnaire, were collected from all the participants immediately prior to the teaching intervention. A pretest was performed before instruction in the experimental group and the control group. The results of the pretest were used to gain insights into the AMNR participants' knowledge. The students in each session were taught the same content weekly during a 4-month intervention period. Five MCQ review tests concerning the content covered in class were performed by the experimental group students using SIDRA, and each one took place just before the end of a class. The same MCQ review questions were answered by the control group students using a "hand raise" response. A final examination took place immediately following the instructional period. The results of this posttest were used to evaluate the effectiveness of SIDRA as an instructional tool. Finally, a questionnaire was administered to evaluate the students' experience of the use of SIDRA.

Teaching Interventions

Two teaching methods were compared and designed to allow the acquisition and retention of AMNR skills and knowledge in the context of nursing practice. Both lasted 15 weeks. Up-to-date literature and teaching resources according to current recommended nursing practice were used to ensure relevant content.

The assignments proposed in AMNR cover different learning objectives in the cognitive domain of Bloom's taxonomy,³⁷ which involves the knowledge and development of intellectual skills. The subjects were the following: health systems and their characteristics, management of health services and nursing services, management of human and material resources, emergency situations, management and security enhancement, management of nursing care quality, and other related subjects.

Conventional Face-to-Face Lecture

The students in the control group (n = 72) were taught in a lecture hall by a team of experienced nurses and supervisors. They were given slides and additional resources to support their learning. Any questions about the subject matter that arose during the experimentation period were answered by the lecturers.

E-Learning With Sistema De Respuesta inmediata de la Audiencia

The participants in the experimental group (n = 58) used SIDRA in class. Five tests of four MCQs with four potential answers related to AMNR were proposed. The questions ranged from trivial questions to more complex nursing problems in which a short response time was required (eg, a case study on the reinforcement of human resources in an emergency room when a head-on collision of trains occurs in a city). All of the MCQs considered quality factors.³⁸

During this time, the faculties launched online tests, whereas the students answered questions by using the SIDRA Web client. At the end of each test, the immediate feedback given by SIDRA provided the instructors with guidance as regards knowing the students' knowledge status. The instructors could also follow the students' evolution and identify the best students by using the SIDRA Web client. From the point of view of the students, information was also immediate when comparing their answers anonymously with those of the rest of the group. The instructors and students could analyze the difficulty of the questions and discuss the different responses in class.

Outcome Measures

In October 2012, baseline knowledge was gathered by means of Sakai, the learning management system used at the University of Murcia. Knowledge gains were measured

in a final examination by using an MCQ test that consisted of 40 questions about different aspects of AMNR, administered using Sakai. The students took this examination in January 2013, after the course had finished.

Analysis

The data collected were analyzed, and figures were generated by using SPSS 19.0 (IBM, Armonk, NY) and Microsoft Office Excel 2010 (Microsoft, Redmond, WA). The χ^2 analysis was used to determine any differences between the demographic characteristics of the students in the experimental and control groups. The Kolmogorov-Smirnov statistical test was used to verify that the two study groups had a normal distribution. The Student *t* test for independent samples was used to estimate significant differences in the knowledge test scores between the experimental group and the control group, and a conventional significance level of .05 was used to detect differences. The equality of variances was checked by using the Levene test. Pearson correlation coefficient was also used to measure the strength of the association between two variables.

RESULTS

There was diversity among the 130 nursing students in relation to age, gender, and educational background. The participants were aged between 20 and 49 years, with a mean of 27.04 years and a mode of 20 years. Most of the participants were female (85.38%, n = 111) with a mixed educational background. A χ^2 test comparing the participants' characteristics, which included gender, age, and educational background, was performed at baseline. No significant differences were found between the experimental and control groups.

This study used one independent variable (learning method) and one dependent variable (AMNR knowledge and skills). The students were scored from 0 to 4 in practice and from 0 to 6 in theory. Their final examination grades were calculated by adding the theory and practice scores, from 0 to 10. Means, SDs, modes, and medians of the final examination marks for both the control and experimental groups are summarized in Table 1.

Note that when the scores obtained by the experimental group and the control group were compared, significant

Table 1
Statistical Results of the Activities Proposed in SIDRA

Statistics	MN		SD		MD		MDN		t Test
Phase	Exp	Ctr	Exp	Ctr	Exp	Ctr	Exp	Ctr	Exp vs Ctr
AMNR	8.43	7.60	0.95	2.08	8.77	0	8.67	8.16	$t_{128} = 2.80, P = .005$

Abbreviations: Exp, experimental; Ctr, control; MN, mean; MD, mode; MDN, median; *t* test, Student *T* test for independent samples.

differences were detected in the final examination ($t_{128} = 2.80$, $P = .005$). Hypothesis 1 was therefore supported.

By using Pearson correlation coefficient for the experimental group data, a positive linear correlation (0.27) between the students' scores obtained in SIDRA and the AMNR final examination marks was observed, thus partially supporting hypothesis 2. Moreover, a negative linear correlation (-0.30) between the students' scores obtained in SIDRA and their average response times was obtained. This signifies that the students with higher scores in the SIDRA tests were those who responded more quickly to the questions formulated. The average response time as regards correct answers was 23.74 seconds, whereas the average response time as regards incorrect answers was 26.87 seconds. Figure 2 shows the average response time per question obtained from SIDRA. The instructors identified those emergency situations in which more time was required to make a decision.

Student Satisfaction

The subjects in the experimental group were asked to complete a questionnaire about their experience with SIDRA. Fifteen questions were rated on a five-point Likert-type scale, and four open questions were answered. The survey aimed to measure the students' satisfaction and motivation when using SIDRA and to collect data on their opinions as regards their learning process. A total of 21 experimental group students (36.20%) completed the survey.

Most of the students (76.19%) reported that the SIDRA activities had improved (considerably or a lot) their learning process on the course. They perceived a good or very good SIDRA response time (76.19%) and found the interface to be friendly (71.42%). It is particularly curious that the preferred device on which to use SIDRA was the laptop (52.38%), probably owing to the low percentage of AMNR students with a smartphone. Note that little literature is available on the use of smartphones in nursing education.³⁹

In the open questions, most of the students (52.38%) reported that SIDRA allows them to perform a self-

assessment of their knowledge, which they can then use to identify their individual learning objectives. Learners can focus their attention on topics for which they need particular help, as demonstrated by their own performance when using SIDRA. Another student highlighted SIDRA's capacity to evaluate knowledge in a dynamic and amusing manner.

Finally, the SIDRA activities were positively evaluated by the students (on a scale of 0–10; mean, 8.76 [SD, 0.99]), thus supporting hypothesis 3. Our findings are in accordance with the majority of studies in literature that have reported a high level of satisfaction in terms of the immediacy of feedback and better understanding of the content.^{30,32,35}

DISCUSSION

The aim of this study was to compare the effects of using ARS versus a conventional teaching method as regards the acquisition of knowledge on an AMNR course. As stated in literature, the results of our study revealed that SIDRA produced significant cognitive gains for the students from the experimental group in the final examination.^{30,35} In line with other studies, these students tended to be more attentive and interested during lectures, thus keeping up with the course contents, since they were asked about this every 3 weeks.^{23,30} As previous studies have shown, active student participation was associated with gains in educational achievement.⁴⁰ Moreover, the students received feedback on their answers at the end of the theory sessions, which promoted reflective thinking, as suggested in the literature reviewed.⁴ The misconceptions were identified, and explanations were offered immediately, thus giving rise to lectures guided by student input.¹³ In particular, the instructors identified difficulties in assigning greater urgency to some criteria than to others. For example, most of the students (88.46%) responded that calls for assistance do not have to be made early when noting clinical signs of cardiac arrest in patients returning from the operating theater. These misconceptions were addressed without delay in class while allowing the instructors to adjust their lesson plans accordingly.

Our results therefore supported findings in literature that reported the efficacy of “clickers” as a formative assessment tool.^{30,31} These results refute previous studies, which claim that no changes are achieved in nursing students' examination performances when using an ARS.²⁸

As suggested in other studies, the anonymity increased student participation, since those students who were shy or worried that their mispronunciations might be misunderstood were not afraid to take part.^{24,41} The SIDRA process allowed educators to anonymously assess knowledge base, comprehension, and recall. The students were active members in the classroom, and discussion groups were organized to address any misconceptions identified.

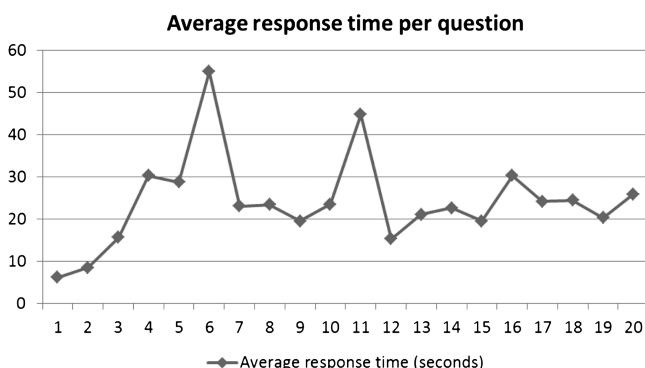


FIGURE 2. Average response time per question in five SIDRA tests.

The students also found benefits as regards comparing their anonymous answers with those of the rest of the group even when they were wrong, since they liked knowing that they were “not alone.”^{21,42} Moreover, anonymity was particularly important in increasing student participation in large classes (between 60 and 80 students per class).

The measurement of response times during the SIDRA activities also allowed the instructors to know the students’ reaction times when confronted with the critical situations involved in managing nursing resources. A prospective study conducted in a 750-bed tertiary care university-affiliated hospital analyzed the time taken for medical care to be delivered to patients who had deteriorated unexpectedly on a hospital ward.⁴³ This study demonstrated that the two most important components that contributed to delays were the time taken by nursing staff to activate a call for assistance and, where needed, for physicians to call for higher-level care. This feature of SIDRA may therefore be extremely useful in topics related to decision making and can be explored by other instructors, since SIDRA is publicly available.

It might be interesting to note whether it is possible for improvements in the speed of response by using SIDRA, in other words speed at being able to make a decision in a critical situation, to be transferred from the classroom to the clinical setting, and this is an open issue. The instructors who supervised SIDRA students when performing clinical practice in hospital units were contacted. It was noticed that the students who had correctly responded more quickly to the questions formulated in SIDRA were able to make correct and prompt decisions in real emergency situation. However, exceptional critical scenarios were identified in which students with low response times in SIDRA were not able to manage a real clinical setting appropriately. These situations typically required training in highly specialized and complex clinical skills. This is the case of, for example, a respiratory insufficiency in a patient who needs orotracheal intubation and mechanical ventilation. Since a quantitative data analysis was not undertaken, this is a subject for further research.

Limitations

Three limitations were found in the study. First, a rise in students’ grades with regard to previous years was observed. The reason for this phenomenon may be explained by the fact that many students were motivated by the increase in tuition fees for the second enrollment. They had a very high workload in the form of 13 seminars, 15 lectures, and a final examination. However, the students had sufficient energy to prepare for the tests properly, as was confirmed in the satisfaction survey. Although findings must be interpreted with caution, we believe that intervention conditions did not affect either the control group or

the experimental group in a differential manner and are not thus a threat to the conclusion validity. Another factor to take into account in the e-learning process is the technology used. Although the technology needed to use an ARS is relatively easy to operate and requires only an intermediate level of computer skills, the malfunctioning of remote devices can be a serious problem.^{3,23,33,34,44} Two nursing students had severe difficulties when interacting with SIDRA owing to connectivity problems. They were frustrated with the computer technology and needed technical support. The nursing instructors were also affected by this problem, but it was overcome with great willingness on the part of all. More specifically, there were some problems of a technological nature with regard to the inclusion of questions in the SIDRA Web server. The nursing faculty had to rely on computer experts (SIDRA administrators) owing to a lack of computer literacy. On overcoming these difficulties, the proposal presented provides an interesting learning instrument to be integrated into any nursing course. A third limitation was the nonrandom assignment of the sample. The students were assigned to the morning or afternoon session according to their surnames, in alphabetical order. However, this limitation was addressed by performing a pretest before the instruction in the experimental and control groups, to check that the students had the same baseline knowledge of core concepts.

CONCLUSIONS

Although there are certain commonalities, each type of ARS contains its own features that must be considered when using them in a teaching method or strategy. Their selection depends on the course contents, the instructor, the learner, and the technological environment. Instructors must evaluate the implication of any ARS they choose to use in each specific circumstance and plan each online activity accordingly, based on the instructional needs of the intended audience.⁴⁵

One of the main disadvantages of an ARS is the high cost of the remote devices.^{3,23,33} In the case of SIDRA, the remote device can be replaced with a smartphone, which could lead to a wider adoption of ARS in educational institutions with a low budget.³⁹ In the future, we intend to apply the approach to non-health-related disciplines in order to better support conclusiveness as to the effectiveness of SIDRA features. We also plan to extend SIDRA by using an intelligent analysis of student responses, with the aim of classifying groups of students according to their knowledge level and generating diagnostic feedback.^{46–48}

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